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# An interdisciplinary approach in "Zone-Atelier Territoires Uranifères" (ZATU) to highlight the trace of uranium mining heritage

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## Résumé

Uranium mining and milling activities as well as mineral processing plants raise environmental concerns due to the possible release of radioactive and other potentially toxic elements. Therefore, their long-term management requires knowledge of past events and a good understanding of the geochemical mechanisms regulating the mobility of residual radionuclides. This work presents the results on the traces and footprints of anthropic activity, linked to past U mining activities, within the vicinity of Rophin tailings storage site (Puy de Dôme, France). An interdisciplinary approach was developed based on a study of the history and records of the site, on the radiological and chemical characterization of soil cores and on dendrochronology. Gamma survey measurements on the wetland about 200m downstream of Rophin reach 1050 nSv.h-1 that is 3 times the geological background radiation levels. Soil cores taken in the wetland showed U concentrations up to 1855 mg.kg-1 that appears to be associated with the presence of a whitish silt loam (WSL) soil layer located at around 10-30 cm depth below an organic top soil layer. Records (regulatory documents, inspection reports, letters) supported by former aerial photographs suggest the discharge of U mineral particles during the operation of the site between 1949 and 1957, due to malfunction of the ore washing plant process and the sedimentation step. In accordance with previous findings, analysis of <sup>137</sup>Cs and <sup>14</sup>C activities date the WSL layer back to the beginning of the 1950s. Moreover, lead isotope ratios indicates that contamination in the WSL layer can be discriminated by an enrichment signature with a larger contribution of radiogenic lead to total lead ( $k = 8.6 \pm 0.07 \%$ ). The dendroanalysis permits to link the U emissions from Rophin with the site

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history using oak tree rings as a suitable bioindicator of changes in bioavailable U concentrations. Oak tree rings (*Quercus petraea*) located downstream of the site contain uranium concentrations up to 50  $\mu\text{g.kg}^{-1}$ , which is up to ten times higher than values measured from unaffected trees located upstream. Moreover, highest U concentrations were recorded for the exploitation period but also, more surprisingly, for the recent makeovers of the Rophin site (2002 and 2010). This interdisciplinary investigation give clear insights of what happened in the vicinity of Rophin tailings storage site. All complementary fields of study corroborate that U mineral particles were transported by turbid waters in Rophin's watershed. While initially transported as mineral particles, at least the majority of the deposited uranium in WSL layer appears to be trapped in the top soil layer with a high organic matter content. However it evolution should be monitored to understand the the overall dynamics occurring at the site.

**Mots-Clés:** ZATU, site minier, histoire, contamination, dendrologie, radiochimie, archives, géochimie